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Interface Requirements Document between the Earth Observing System Data and Information System (EOSDIS) and the AM Project for AM-1 Flight Operations

July 1995

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

Interface Requirements Document

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Earth Observing System Data and Information System (EOSDIS)

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AM Project for AM-1 Flight Operations System

Approved by:

_____ _____

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GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

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AM Project for AM-1 Flight Operations System

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Preface

This document is a formal contract deliverable with an approval code 1. It requires Government review and approval prior to acceptance and use. Changes to this document also require Government approval prior to acceptance and use. Changes to this document shall be made by document change notice (DCN) or by complete revision.

This document is under ESDIS Project Configuration Control. Any questions or proposed changes should be addressed to:

ESDIS PROJECT
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Code 505

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Abstract

The Earth Observing System Data and Information System (EOSDIS) Core System (ECS) involves the collection and distribution of data from space and ground based measurement systems to provide the scientific basis for understanding global change. Using ECS as their window to the EOSDIS, the international science community is able to access data from a distributed archive in the United States and from other international Earth Science support systems. To accomplish this mission, it is necessary for ECS to interface with a wide variety of external systems. This document represents the requirements to provide and interface between ECS and the Earth Observing System (EOS) AM Project for AM-1 Flight Operations.

The ECS contractor team used the process described in the ECS Methodology for Definition of External Interfaces document to develop these interface requirements. Level 2 and Level 3 Requirement Specifications were used in the methodology to evolve this formal Interface Requirements Document (IRD).

This document supersedes the following preliminary ECS Interface Requirements Documents (IRDs) which were delivered in August 1993:

193-219-SE1-012, Interface Requirements Document Between ECS and NASA Code 421/AM Spacecraft Simulator;

193-219-SE1-013, Interface Requirements Document Between ECS and Code 421 (AM Spacecraft) Spacecraft and Instrument Databases (SDB and IDBs);

193-219-SE1-014, Interface Requirements Document Between ECS and Code 421 (AM Spacecraft) Principal Investigators/Team Leads.

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Contents

4. Data Flow Descriptions

5. Functional and Performance Interface Requirements

6. Interface Control Documentation Plan

Abbreviations and Acronyms

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1. Introduction

1.1 Identification

This Interface Requirements Document (IRD), Contract Data Requirement List (CDRL) Item 039, whose requirements are specified in Data Item Description (DID) 219/SE1, is a required deliverable under the Earth Observing System Data and Information System (EOSDIS) Core System (ECS), Contract (NAS5-60000). It defines the interface requirements between ECS and the Earth Observing System (EOS) AM Project for AM-1 Flight Operations.

1.2 Scope

This IRD defines the system interfaces that exist between ECS and the EOS AM Project in support of AM-1 flight operations. Specifically, this document addresses ECS external interfaces that involve transmission/receipt of AM-1 spacecraft command and telemetry; the Spacecraft Simulator (SSIM); delivery of data bases and software, such as AM-1 data base information and spacecraft vendor-developed Spacecraft Analysis Software (SAS); the Instrument Support Terminal (IST) toolkit; AM-1 flight software maintenance; and operations training.

There are other ECS documents that are applicable to AM-1 instrument and data processing interfaces with the ECS. Interfaces supporting the Japanese Ministry of International Trade and Industry (MITI) Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument are defined in the IRD Between ECS and MITI ASTER Project. Interfaces between instrument Science Computing Facilities (SCFs) and the ECS for algorithm integration and test are defined in the IRD Between ECS and Science Computing Facilities. AM-1 interfaces involving other components of EOSDIS, such as those with the EOS Data and Operations System (EDOS), are addressed in other documents, as appropriate (refer to Section 2 for a listing of related documentation).

The Functional and Performance Requirements Specification for the EOSDIS Core System defines the ECS system requirements and user interface requirements, including requirements for the ECS IST toolkit and the general ECS science user interface for ordering science data products and AM-1 spacecraft data (archived telemetry, history logs, etc.) from ECS archives. ECS requirements for AM-1 instrument science data processing also are documented in the Functional and Performance Requirements Specification for the EOSDIS Core System .

ECS mission-specific requirements related to AM-1 flight operations will be defined in detail in the ECS Segment Requirements Specification, DID 304/DV1. This document will be available for AM-1 project review prior to being placed under Earth Science Data and Information System (ESDIS) Project configuration control.

This document supersedes the following preliminary ECS IRDs which were delivered in August 1993:

193-219-SE1-012, Interface Requirements Document Between ECS and NASA Code 421/AM Spacecraft Simulator;

193-219-SE1-013, Interface Requirements Document Between ECS and Code 421 (AM Spacecraft) Spacecraft and Instrument Databases (SDB and IDBs);

193-219-SE1-014, Interface Requirements Document Between ECS and Code 421 (AM Spacecraft) Principal Investigators/Team Leads.

This IRD will be approved under the signature of the ESDIS Project Manager.

1.3 Purpose and Objectives

This document is written to formalize the interpretation and general understanding of the interface between ECS and EOS AM Project and to provide a point of mutual control of external interface definitions for the ESDIS Configuration Control Board (CCB) and the CCB(s) serving the EOS AM Project**.**

The objective of this document is to provide a focus for defining related Interface Control Documents (ICDs) and other lower level documents which will be jointly developed for each major subsystem interface identified in this IRD.

1.4 Status and Schedule

This document has been approved by the ECS Contractor CCB as a final IRD. As a formal contract deliverable with Approval Code 1, this document requires Government review and approval prior to acceptance and use. At the Government’s option, this document may be designated to be under full Government CCB control.

Changes may be submitted for consideration by Contractor and Government CCBs under the normal change process at any time.

1.5 Document Organization

This Interface Requirements Document is organized as described below:

Section 1	Introduction - Introduces the IRD's scope, purpose, objectives, status, schedule, and document organization.
Section 2	Related Documentation - Provides a bibliography of reference documents for the IRD organized by parent, applicable, and information subsections.
Section 3	Systems Description - Provides an overview of both systems and a discussion of the system components involved in the interface. A context diagram depicting the functional interfaces also is included.

Section 4	Data Flow Descriptions - Provides a discussion of how the interface is used from an operational point of view. A table is also provided to summarize the data flow interfaces.
Section 5	Functional and Performance Interface Requirements - Requirements are sorted for presentation by denoting functional or performance type. Traceability to parent documents also is noted in this section.
Section 6	Interface Control Documentation Plan - Identifies and summarizes the ICD(s) that will spawn from this IRD.

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2. Related Documentation

2.1 Parent Documents

The following documents are the parents from which this document's scope and content derive:

GSFC170-01-01	Execution Phase Project Plan for Earth Observing System (EOS), September 24, 1994.
GSFC 423-41-02	Goddard Space Flight Center, Functional and Performance Requirements Specification for the Earth Observing System Data and Information System (EOSDIS) Core System, June 2, 1994
GSFC 423-10-01-1	Goddard Space Flight Center, Earth Science Data and Information System (ESDIS) Project -- Level 2 Requirements, May 21, 1993
GSFC 423-41-01	Goddard Space Flight Center, EOSDIS Core System Statement of Work, June 2, 1994
301-CD-002-003	EOSDIS Core System Project, System Implementation Plan for the ECS Project
193-208-SE1-001	EOSDIS Core System Project, Methodology for Definition of External Interfaces
	Interproject Agreement Between AM and ESDIS Projects on Flight Operations for the AM-1 Spacecraft, November 21, 1994 (under development)
	Detailed Mission Requirements (DMR) for the AM-1 Spacecraft, July 1994

2.2 Applicable Documents

The following documents are referenced herein and are directly applicable to this document. In the event of conflict between any of these documents and this document, this document shall take precedence.

EDCN-0868	Lockheed Martin, EOS-AM Ground System Requirements Database, Version 2; 4/28/95
194-219-SE1-002	EOSDIS Core System Project, IRD Between ECS and MITI ASTER Project
540-022	Goddard Space Flight Center/MO&DSD, Earth Observing System (EOS) Communications (Ecom) Interface Requirements Document, March 1993

560-EDOS-0211.0001	Goddard Space Flight Center/MO&DSD, Interface Requirements Document Between EDOS and the EOS Ground System (EGS) Elements, Preliminary, August 1994
560-EDOS-0211.0003	Goddard Space Flight Center/MO&DSD, Interface Requirements Document Between EDOS and the TDRSS Ground Terminal (TGT), December 1992, (DCN 001)
560-EDOS-0211.0004	Goddard Space Flight Center/MO&DSD, Interface Requirements Document Between EDOS and Ecom, March 17, 1994 (DCN 007)
560-EDOS-0230.0001	Goddard Space Flight Center/MO&DSD, Earth Observing System (EOS) Data and Operations System (EDOS) Data Format Requirements Document (DFRD), December 1992
GSFC 423-35-01	Goddard Space Flight Center/MO&DSD, EOS Data and Operations System (EDOS) and EOS Communications (Ecom) Requirements, March 1992 (through CH19)
540-029	Goddard Space Flight Center/MO&DSD, Earth Observing System (EOS) Communications (Ecom) Functional and Performance Requirements Specification, March 1993

2.3 Information Documents

The following documents, although not directly applicable, amplify or clarify the information presented in this document, but are not binding.

Martin Marietta Corporation, EOS-AM Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Instrument Flight Operations Understanding, August 1993

Martin Marietta Corporation, EOS-AM Measurement of Pollution in the Troposphere (MOPITT) Instrument Flight Operations Understanding, August 1993

Martin Marietta Corporation, EOS-AM Moderate Resolution Imaging Spectroradiometer (MODIS) Instrument Flight Operations Understanding, August 1993

Martin Marietta Corporation, EOS-AM Multi-Angle Imaging Spectro-Radiometer (MISR) Instrument Flight Operations Understanding, August 1993

Martin Marietta Corporation, EOS-AM Spacecraft Clouds and Earth's Radiant Energy System (CERES) Instrument Flight Operations Understanding, August 1993

Goddard Space Flight Center, Earth Observing System Mission Operations Concept Document, August 1993

604-CD-001-003	EOSDIS Core System Project, Operations Concept for the ECS Project: Part 1 -- ECS Overview, Final Draft
194-219-SE1-005	EOSDIS Core System Project, IRD Between ECS and Science Computing Facilities
194-219-SE1-020	EOSDIS Core System Project, IRD Between ECS and NASA Institutional Support Systems
423-003-CO4	EOSDIS Core System Project, Government Furnished Property for the ECS, April 1993
515-ETS-01	Goddard Space Flight Center/MO&DSD, EOSDIS Test System (ETS) Operations Concept, December 1993
515-ETS-02	Goddard Space Flight Center/MO&DSD, EOSDIS Test System (ETS) Functional and Performance Requirements, December 1993
540-020	Goddard Space Flight Center/MO&DSD, Earth Observing System (EOS) Communications (Ecom) System Design Specification, April 1994
540-028	Goddard Space Flight Center/MO&DSD, Earth Observing System (EOS) Communications (Ecom) Operations Concept Document, March 1993
560-EDOS-0106.0002	Goddard Space Flight Center/MO&DSD, Earth Observing System (EOS) Data and Operations System (EDOS) Operations Concept, December 1992
ICD-103	Martin Marietta Corporation, EOS AM Spacecraft to Launch Vehicle Interface Requirements Document, August 26, 1992
ICD-104	Martin Marietta Corporation, EOS AM Spacecraft to STDN Interface Control Document, August 1994
ICD-105	Martin Marietta Corporation, EOS AM Spacecraft to WFF Interface Control Document, August 1994
ICD-106	Martin Marietta Corporation, Interface Control Document (ICD) Data Format Control Book for EOS-AM Spacecraft, April 1994
JPL D-11594	Jet Propulsion Laboratory/California Institute of Technology, Multi-angle Imaging Spectro-Radiometer (MISR) Mission Operations Concept and Requirements, April 8, 1994
OPD-120	Martin Marietta Corporation, Spacecraft Operations Concept Document, May 15, 1992
OPD-30	Martin Marietta Corporation, Ground System Sustaining Engineering Plan

OPD-310	Martin Marietta Corporation, Simulation Plan
OPD-320	Martin Marietta Corporation, Ground System Operations Readiness Test Plan
OPD-410	Martin Marietta Corporation, Training Plan
OPD-810	Martin Marietta Corporation, Spacecraft Sustaining Engineering Plan
SP-991	Martin Marietta Corporation, Spacecraft Simulator (SSIM) Requirements Document, June 30, 1993

3. Systems Descriptions

3.1 Systems Relationship Overview

ECS provides ground support for EOS AM-1 spacecraft and instrument mission operations. This support includes mission planning, scheduling, control, monitoring, and analysis for the AM-1 spacecraft and its instruments. The ECS and the AM-1 Project elements interface during the pre-launch testing, spacecraft launch, post-launch check-out, and on-orbit operations phases of AM-1 support. Sections 3.2 and 3.3 provide overall views of the ECS and the AM-1 elements. Sections 3.4 through 3.10 provide background information on some of the external elements which support the ECS/AM-1 interface. Figure 3-1 presents a context diagram for the interfaces between the ECS and the AM-1 elements.

3.2 EOSDIS Core System (ECS)

3.2.1 ECS Overview

ECS, EDOS, and EOS Communications (Ecom) network are components of the EOSDIS. ECS supports the planning, scheduling, and control of U.S. EOS spacecraft and instruments. In addition to fully supporting the EOS series, the ECS provides information management and data archive and distribution functions for other NASA Earth science flight missions, NASA instruments flown on non-NASA flight missions, and for other NASA held Earth science data.

3.2.2 ECS Segments

ECS is composed of three segments defined to support three major operational areas: flight operations, science data processing, and communications/system management. The ECS segments are described below:

a. The Flight Operations Segment (FOS) manages and controls the U.S. EOS spacecraft and instruments. The FOS includes the EOS Operations Center (EOC), which is responsible for mission planning, scheduling, control, monitoring, and analysis in support of mission operations for U.S. EOS spacecraft and instruments. The ECS EOC is located at the Goddard Space Flight Center (GSFC). The FOS also provides investigator-site ECS software (the Instrument Support Terminal [IST] toolkit) to connect a Principal Investigator (PI) or Team Leader (TL) to the FOS in remote support of instrument control and monitoring. (Investigator facilities are outside the FOS, but connected to it by way of the EOSDIS Science Network [ESN] Wide Area Network [WAN] or the NASA Science Internet [NSI].)

b. The Science Data Processing Segment (SDPS) provides a set of ingest, processing, and distribution services for science data and a data information system for the entire EOSDIS. The SDPS processes data from the EOS instruments to Level 1-4 data products.

The SDPS also provides short- and long-term storage for EOS, other Earth observing missions, and other related data, software, and results, and distributes the data to EOSDIS users. The SDPS contains a distributed data and information management function and user services suite for the ECS, including a catalog system in support of user data selection and ordering. SDPS elements will be distributed at the following Distributed Active Archive Centers (DAACs):

1. Goddard Space Flight Center (GSFC), Greenbelt, Maryland
2. Earth Resources Observation System (EROS) Data Center (EDC), Sioux Falls, South Dakota
3. Jet Propulsion Laboratory (JPL), Pasadena, California
4. Langley Research Center (LaRC), Hampton, Virginia
5. University of Colorado, National Snow and Ice Data Center (NSIDC), Boulder, Colorado
6. University of Alaska, Alaska Synthetic Aperture Radar (SAR) Facility (ASF), Fairbanks, Alaska*
7. Marshall Space Flight Center (MSFC), Huntsville, Alabama
8. Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee*
9. Socioeconomic Data and Applications Center (SEDAC), Saginaw, Michigan*

*These DAACs have no ECS-provided product generation capability. ECS will provide no hardware or operations support to SEDAC, but will make ECS software available for reuse.

c. The Communications and System Management Segment (CSMS) provides overall ECS management of ECS ground system resources, provides communications/networking services for an extensive science data communications network, and manages the interfaces to the Ecom network, the NASA Communications (Nascom) Local Area Network (NOLAN), and the NASA Science Internet (NSI). The CSMS also includes the ESN, which consists of a dedicated internal ECS Wide Area Network (WAN) with circuits provided by the Program Support Communications Network (PSCN); Local Area Networks (LANs) at each of the DAACs and the EOC to support ECS operations; connections to International Partners (IPs); and interfaces at DAACs with Ecom, NOLAN, and NSI. The CSMS System Management Center (SMC), along with local system management capabilities at DAAC sites and the EOC, provides system management services for ECS ground system resources. Most of the operations staff is considered part of the SDPS or FOS, including Local System Management (LSM) operators.

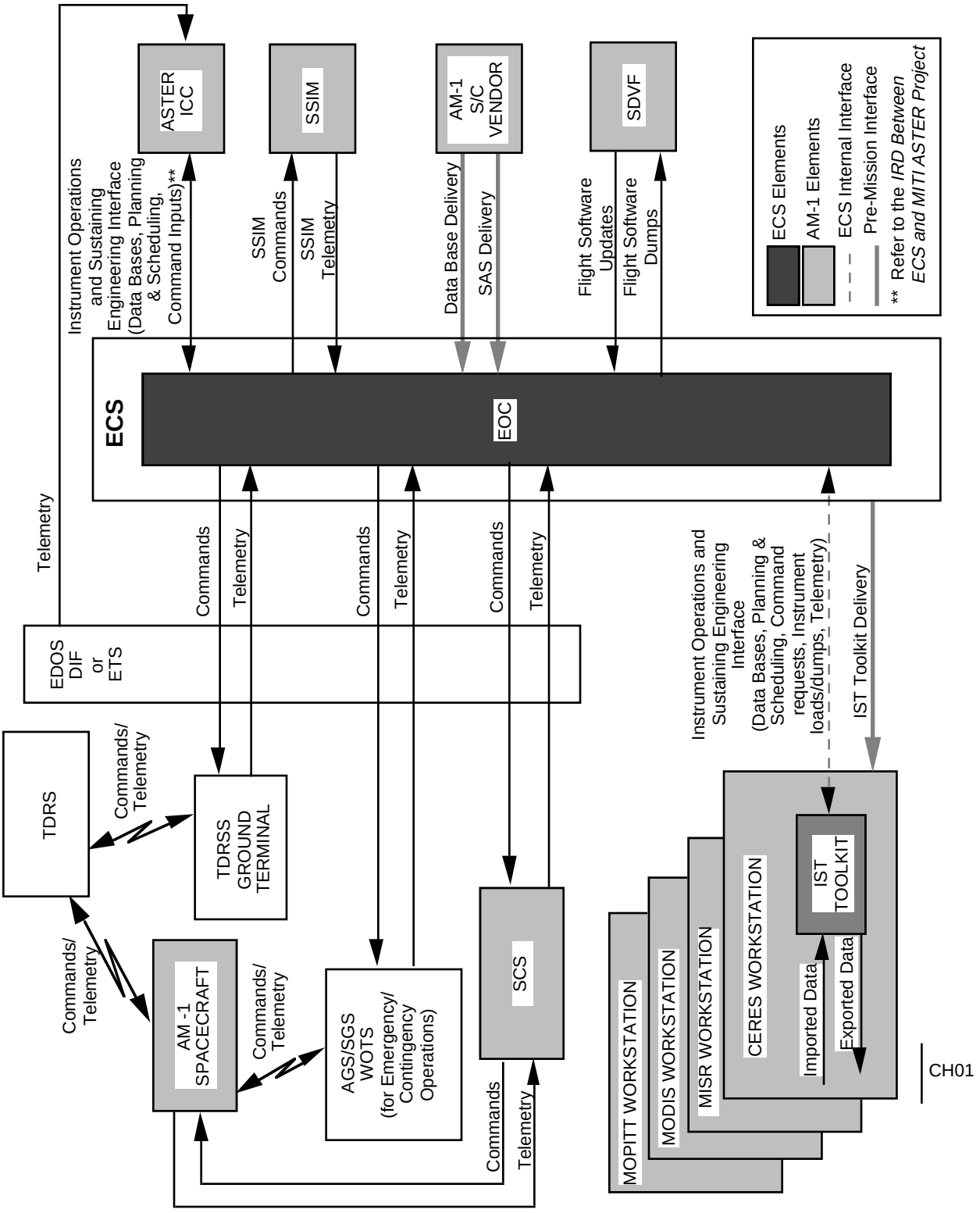

Figure 3-1. ECS/AM-1 Interface Context Diagram

3.3 AM-1 Elements

3.3.1 AM-1 Spacecraft

The AM-1 spacecraft is the first of the EOS AM (morning equatorial crossing) missions. Built and integrated by the AM-1 spacecraft vendor at their facility in Valley Forge, Pennsylvania, the AM-1 spacecraft will be placed in a sun-synchronous orbit at an altitude of approximately 705 kilometers by an intermediate class launch vehicle. AM-1 launch is currently scheduled to occur in mid-1998.

The AM-1 spacecraft is conceptually partitioned into eight subsystems: Structures and Mechanisms Subsystem (SMS); Thermal Control Subsystem (TCS); Propulsion Subsystem (PROPS); Electrical Power Subsystem (EPS); Electrical Accommodation Subsystem (EAS); Guidance, Navigation, and Control Subsystem (GN&CS); Command and Data Handling Subsystem (C&DHS); and Communication Subsystem (COMMS).

Within the C&DHS, redundant Spacecraft Control Computers (SCCs) support the execution of application software for spacecraft subsystems and instruments, including the storage and processing of stored commands. The C&DHS, command and telemetry interface units (CTIUs) provide the communication interface with the COMMS for uplinked commands and for housekeeping telemetry. The C&DHS, Science Formatting Equipment (SFE) formats instrument science data (in the form of CCSDS source packets) into Consultative Committee for Space Data Systems (CCSDS) Channel Access Data Units (CADUs) and routes them to the COMMS and the spacecraft recorder.

The COMMS consists of a high gain antenna (HGA), S-band Omni antenna system, Ku-band single access (KSA) modulator, S-band transponder and interface unit, a 4 megahertz (MHz) master oscillator and a Direct Access System (DAS). The DAS is composed of the Direct Playback (DP) subsystem, the Direct Broadcast (DB) subsystem, and the Direct Downlink (DDL) subsystem. While it is planned that all science data will be downlinked via the NASA Tracking and Data Relay Satellite System (TDRSS), the DAS allows for direct transmission of onboard data to ground receiving stations via an X-band transmitter.

3.3.2 AM-1 Instruments

The AM-1 payload complement consists of five instruments: Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Clouds and Earth's Radiant Energy System (CERES), Multi-angle Imaging SpectroRadiometer (MISR), Moderate Resolution Imaging SpectroRadiometer (MODIS), and Measurements Of Pollution In The Troposphere (MOPITT). Facility Instrument operations are coordinated by Team Leads (TLs). The Facility Instruments on AM-1 are ASTER and MODIS. CERES, MISR and MOPITT operations are coordinated by their principal investigators (PIs). The following paragraphs provide brief descriptions of the AM-1 instruments.

3.3.2.1 ASTER

The ASTER instrument is a high-resolution multi-spectral imaging radiometer provided by Japan's MITI. ASTER provides high spatial resolution images of land surfaces, water, ice, and clouds. ASTER will operate in three visible and near infrared (VNIR) channels, six shortwave infrared (SWIR) channels and five thermal infrared (TIR) channels. ASTER also has a same-orbit stereo imaging capability. The ASTER instrument will be controlled from an Instrument Control Center (ICC) which will be developed by the Japanese as part of the ASTER Ground Data System (GDS). Interface requirements between the ASTER GDS and the ECS are documented in the IRD Between ECS and MITI ASTER Project.

3.3.2.2 CERES

The CERES investigation will provide EOS with an accurate and self-consistent cloud and radiation database for researchers of the World Climate Research Program, including the Tropical Ocean Global Atmosphere campaign, World Ocean Circulation Experiment, and the Global Energy and Water Experiment. The CERES instrument will measure the Earth’s radiation budget through observation of both short- and long-wave radiation using two broad band scanning radiometers. The two identical scanners will normally operate in two different scan modes: cross-track or biaxial. The CERES sensor system consists of three co-aligned broad band thermistor bolometer detectors. The three detectors are identical except for optical filters on two detectors (longwave and shortwave) which restrict their spectral ranges to a portion of the Earth's radiation bandwidth. Each CERES unit has dedicated microprocessors to control and direct instrument operations. Reprogramming the instrument microprocessors is expected to be infrequent. Updates to the instrument microprocessor flight software, scan table, or internal sequences will be uplinked through the EOC as part of an integrated command load. The CERES PI facility is located at LaRC in Hampton, Virginia.

3.3.2.3 MISR

MISR is an instrument for studying the ecology and climate of the earth. The MISR investigation also will be used to validate and correct MODIS and ASTER images. MISR will acquire images at nine discrete viewing angles, with a charged coupled device (CCD) camera allocated to each viewing direction. Four cameras are pointed forward, one pointed at nadir, and four pointed aft. Images at each angle are obtained in four spectral bands using CCD line arrays for a total of 36 channels (nine cameras, four bands each). Each of the 36 instrument data channels is individually commandable to one of four averaging modes (i.e., one-sample-by-one-line [no averaging], two sample-by-two-line, four-sample-by-four-line, and one-sample-by-four-line). MISR targeting is controlled by a table of sites stored in the instrument microprocessor. Instrument microprocessor loads, table loads, and memory loads will be uplinked through the EOC as part of an integrated command load. The MISR PI facility is located at JPL.

3.3.2.4 MODIS

MODIS is designed to measure biological and physical processes on a global scale. The instrument will provide long-term observations from which to derive and enhanced knowledge of

global dynamics and processes occurring on the surface of the Earth and in the lower atmosphere. The MODIS instrument uses a conventional imaging radiometer concept, consisting of a cross-track scan mirror and collecting optics, and a set of linear detector arrays, with spectral interference filters located in four focal planes. The optical arrangement will provide imagery in thirty-six discrete bands selected for diagnostic significance in Earth science. MODIS Telemetry and Command Processor (TCP) loads will be uplinked through the EOC as part of the integrated command load. The MODIS TL facility is located at GSFC.

3.3.2.5 MOPITT

The MOPITT instrument, provided by the Canadian Space Agency (CSA), will measure emitted and reflected infrared radiance in the atmospheric column. The MOPITT experiment uses tropospheric carbon monoxide profile as well as carbon monoxide and methane (a greenhouse gas) columns to study how these gases interact with the surface, ocean, and biomass systems. MOPITT is designed as a scanning instrument with four parallel optical chains. Each chain incorporates its own scanning mirror, calibration targets, optics, and correlation cells (pressure modulated gas filters). Each optical chain has two signal paths, each leading to a detector array, with each detector array consisting of four elements. Infrequent instrument microprocessor software and table loads will be uplinked through the EOC as part of the integrated command load. The MOPITT PI facility is located at the University of Toronto, Ontario, Canada.

3.3.3 Spacecraft Checkout Station

The AM-1 Spacecraft Checkout Station (SCS), developed by the AM-1 spacecraft vendor, supports AM-1 pre-launch integration and testing at the AM-1 spacecraft vendor facility in Valley Forge, PA and at the launch site (Vandenberg Air Force Base Western Space and Missile Center). The SCS can be configured to support several testing configurations from spacecraft simulation to full-up spacecraft launch site testing. The SCS can be configured to generate and provide AM-1 telecommand Command Link Transmission Units (CLTUs) to the spacecraft and receive encoded CADUs from the spacecraft. In this configuration, the testing is conducted without EOSDIS ground system (i.e., EOC, Ecom, EDOS) involvement. Optionally, the SCS also can be configured to receive CLTUs from the EOC through an Ecom/EDOS interface and forward these CLTUs to the spacecraft. The SCS also can forward AM-1 telemetry CADUs to the EOC through an Ecom/EDOS interface.

3.3.4 Spacecraft Simulator

The AM-1 Spacecraft Simulator (SSIM), developed by the AM-1 spacecraft vendor, will be located at GSFC Building 32. The purpose of the SSIM is to provide a platform to support operations procedure development and validation, flight operator training, and anomaly investigation support. The SSIM includes flight-like C&DH subsystem hardware, a set of software models for the other spacecraft subsystems, and orbital environment software.

3.3.5 Spacecraft Analysis Software

The Spacecraft Analysis Software (SAS) is a software toolset developed by the AM-1 spacecraft vendor which provides flight performance and evaluation functions for the AM-1 spacecraft. These functions include analyzing spacecraft performance trends, detecting failures, and evaluating subsystem performance. The SAS is based on the AM-1 Flight Software Test Bed.

3.3.6 Software Development and Validation Facility

The AM-1 Software Development and Validation Facility (SDVF) contains flight software development tools and flight software diagnostic tools. The SDVF generates and tests spacecraft flight software updates, and provides the resulting flight software loads to the EOC for uplink to the AM-1 spacecraft. SDVF functions will initially be provided by the Software Development Facility (SDF) at the AM-1 spacecraft contractor's facility. At a time to be specified by the AM Project (after AM-1 launch) spacecraft flight software maintenance activities will transition to Code 512 at GSFC.

3.4 EDOS

EDOS is the EOSDIS component that supports real time and Level 0 data delivery operations for EOS spacecraft. EDOS performs Level 0 data processing, Level 0 Production Data Set (PDS) distribution, and backup data archive services. Communications links between the ECS and EDOS are provided by Ecom.

3.5 Ecom

Ecom is the EOSDIS component that provides the primary communications network for transport of EOS mission critical data. Ecom consists of a Transport Subsystem (TS), a Common Carrier Subsystem (CCS), a Network Management Subsystem (NMS), and an Engineering Support Subsystem (ESS). The TS and the CCS implement the functionality to transport digital data among Ecom users. The TS also includes Frame Encapsulator/Decapsulator (FED) devices which perform User Datagram Protocol/Internet Protocol (UDP/IP) encapsulation and decapsulation of command and telemetry data.

3.6 EOSDIS Test System

The EOSDIS Test System (ETS) provides test capabilities for use in the functional verification of EOSDIS front end components and their associated interfaces, primarily the EDOS interfaces.

3.7 Space Network

The Space Network (SN) elements are the GSFC Network Control Center (NCC) and the TDRSS. The TDRSS ground segment consists of the White Sands Ground Terminal (WSGT) and Second TDRSS Ground Terminal (STGT), located at the WSC in Las Cruces, New Mexico. The TDRSS space segment consists of a constellation of Tracking and Data Relay Satellites

(TDRSs) in geosynchronous orbit which provide S-band Single Access (SSA), S-band Multiple Access (MA), and KSA tracking and data communications services to low earth orbiting satellites. TDRSS support is scheduled and controlled by the NCC. The SN will be used for primary tracking, telemetry, and command (TT&C) operations for the AM-1 spacecraft.

3.8 (Deleted) CH01

3.9 (Deleted) CH01

3.10 Wallops Orbital Tracking Station, Alaska Ground Station, and Svalband Ground Station CH01

The WOTS, located at Wallops Island, Virginia, provides TT&C support for non-TDRSS compatible low earth orbiting satellites, and S-band emergency support for TDRSS-compatible satellites, including the EOS AM-1 spacecraft. The Alaska and Norway ground stations will provide this TT&C support and, in addition, will provide X-band science data capture recorded on magnetic tape that will be shipped to EDOS. The WOTS, AGS and SGS is managed by the GSFC Suborbital Projects and Operations Directorate (Code 800). CH01

3.11 Western Space and Missile Center

The Vandenberg Air Force Base (VAFB) Western Space and Missile Center (WSMC) Space Launch Complex provides the necessary facilities and communications interfaces to support pre-launch and ascent activities for launch vehicles and their payloads. AM-1 is scheduled to be launched from the WSMC on-board an intermediate class launch vehicle in mid-1998.

4. Data Flow Descriptions

4.1 Overview

The ECS/EOS AM-1 Project interfaces are summarized in Table 4-1. Throughout this section, the data flows are identified by the numbers used in this table. These data flow numbers are enclosed in brackets after the first reference to the data flow. Figure 4-1 also provides a simplified data flow diagram of the interfaces which have been identified between ECS and the following AM-1 elements:

a. the AM-1 spacecraft for transmission/receipt of spacecraft and instrument command and telemetry;

b. the AM-1 Spacecraft Simulator (SSIM) for transmission/receipt of test commands and simulated telemetry;

c. the AM-1 spacecraft vendor, for pre-mission delivery of data base files and Spacecraft Analysis Software (SAS) which will be integrated into the EOC;

d. the AM-1 instrument team facilities for delivery of the IST toolkit, use of the IST toolkit for performance of instrument operations support functions, and IST toolkit data import/export;

e. the AM-1 SDVF for flight software loads/updates.

The remainder of this section describes these interfaces at a high level, and sets the context for understanding the functional requirements which are listed in Section 5. Where appropriate, references are made to existing documentation which provide more detailed information.

Table 4-1. ECS/AM-1 Data Flows (1 of 4)

From	*To*	*Data Flow*	*Description*	*Communications Link*	
EOC	AM-1 (via Ecom-EDOS-TDRSS [or AGS/SGS/ WOTS])[1]	Commands [1]	AM-1 spacecraft and instrument commands in CCSDS CLTUs. Data Rate: 10 kbps; 1 kbps; 125 bps; 2 kbps	Ecom	CH01

[1] Command testing configurations also may include the EOSDIS Test System and/or the AM-1 Spacecraft Checkout Station.

Table 4-1. ECS/AM-1 Data Flows (2 of 4)

From	*To*	*Data Flow*	*Description*	*Communications Link*	
AM-1	EOC (via EDOS-EBnet-TDRSS [or WOTS])[2]	Telemetry [2]	AM-1 outputs telemetry data in the form of CADUs; EOC receives telemetry data in the form of EDUs containing CCSDS telemetry packets and CLCWs to EOC. Telemetry packets includ Pe the following: AM-1 real time spacecraft and instrument health & safety/housekeeping data in CCSDS telemetry packets. Data Rates: 1 kbps; 16 kbps. AM-1 recorded spacecraft and instrument housekeeping data in CCSDS telemetry packets (Downlinked from AM-1 at 256 kbps, 512 kbps, or 150 Mbps; transmitted by EDOS to the EOC as rate-buffered data). AM-1 SCC, CTIU, or instrument memory dump data. Data Rates: 1 kbps; 16 kbps.	Ecom	CH01

[2] Telemetry testing configurations also may include the EOSDIS Test System and/or AM-1 Spacecraft Checkout Station.

Table 4-1. ECS/AM-1 Data Flows (3 of 4)

From	*To*	*Data Flow*	*Description*	*Communications Link*
EOC	SSIM	SSIM Commands [3]	AM-1 spacecraft and instrument commands in CCSDS CLTUs. Data Rates: 10 kbps; 1 kbps; 125 bps; 2 kbps.	Will be specified in the ICD Between the EOS AM-1 Spacecraft Simulator and the ECS.
SSIM	EOC	SSIM Telemetry [4][3]	SSIM Telemetry includes the following: AM-1 simulated real time health & safety/housekeeping data. Data Rates: 1 kbps; 16 kbps. AM-1 simulated SCC, CTIU, or instrument memory dump data. Data Rates: 1 kbps; 16 kbps.	Will be specified in the ICD Between the EOS AM-1 Spacecraft Simulator and the ECS.
AM-1 Spacecraft Vendor	EOC	Data Base Delivery [5]	Spacecraft and Instrument data base information	Will be specified in the Data Format Control Document (DFCD) for the EOS AM-1 Project Data Base
AM-1 Spacecraft Vendor	EOC	SAS Delivery [6]	Spacecraft Analysis Software delivery	Not applicable

CH02

[3] The SSIM outputs telemetry in CADU format. The EOC receives the telemetry as CCSDS packets and CLCWs. CADU-to-CCSDS packet/CLCW conversion is performed by the ETS.

Table 4-1. ECS/AM-1 Data Flows (4 of 4)

From	*To*	*Data Flow*	*Description*	*Communications Link*
ECS	PI/TL Workstation	IST Toolkit Delivery [7]	Toolkit Software	ESN or media delivery.
AM-1 PI/TL Workstation	IST Toolkit	Imported Data [8]	Instrument operations/sustaining engineering data (microprocessor/table loads, etc.)	Not applicable
IST Toolkit	PI/TL Workstation	Exported Data [9]	Instrument sustaining engineering/analysis results (microprocessor/table dumps, analysis results, etc.)	Not applicable
SDVF	EOC	Flight Software Updates [10]	AM-1 spacecraft flight software loads and updates.	Will be specified in the ICD Between ECS and the Software Development and Validation Facility for the EOS AM-1 Project.
EOC	SDVF	Flight Software Dumps [11]	AM-1 spacecraft flight software dumps.	Will be specified in the ICD Between ECS and the Software Development and Validation Facility for the EOS AM-1 Project.

4.2 EOC/AM-1 Command and Telemetry Interfaces

4.2.1 On-orbit Operations

Figure 4-2 depicts the indirect interface between ECS and AM-1 for on-orbit command and telemetry operations. ECS/AM-1 communications are supported through interfaces involving EDOS, the SN (TDRSS), the AGS, the SGS and WOTS. The normal EOC/AM-1 interface for command and telemetry is via EDOS and TDRSS. The Detailed Mission Requirements document for the AM-1 Spacecraft contains more information on the command and telemetry transmission links and the purpose for each configuration. The applicable documents and information documents listed in Sections 2.2 and 2.3 also contain more detailed information on these interfaces. CH01

Based on inputs from instrument teams and spacecraft planners, the EOC builds and formats command requests into CCSDS-compliant Command Link Transmission Units (CLTUs) according to the guidelines described in the ICD Data Format Control Book for the EOS-AM

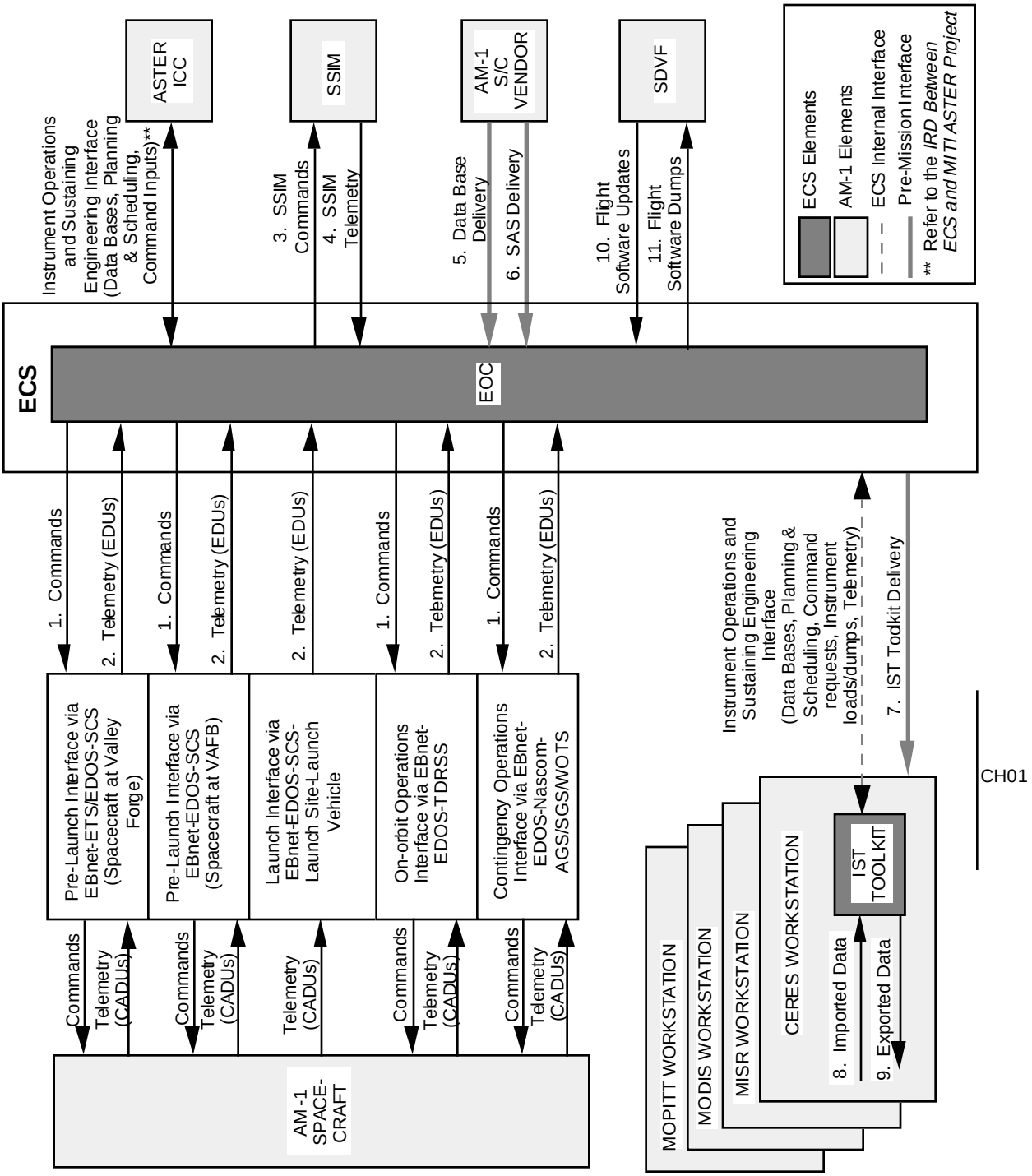

Figure 4-1. ECS/AM-1 Data Flow Diagram

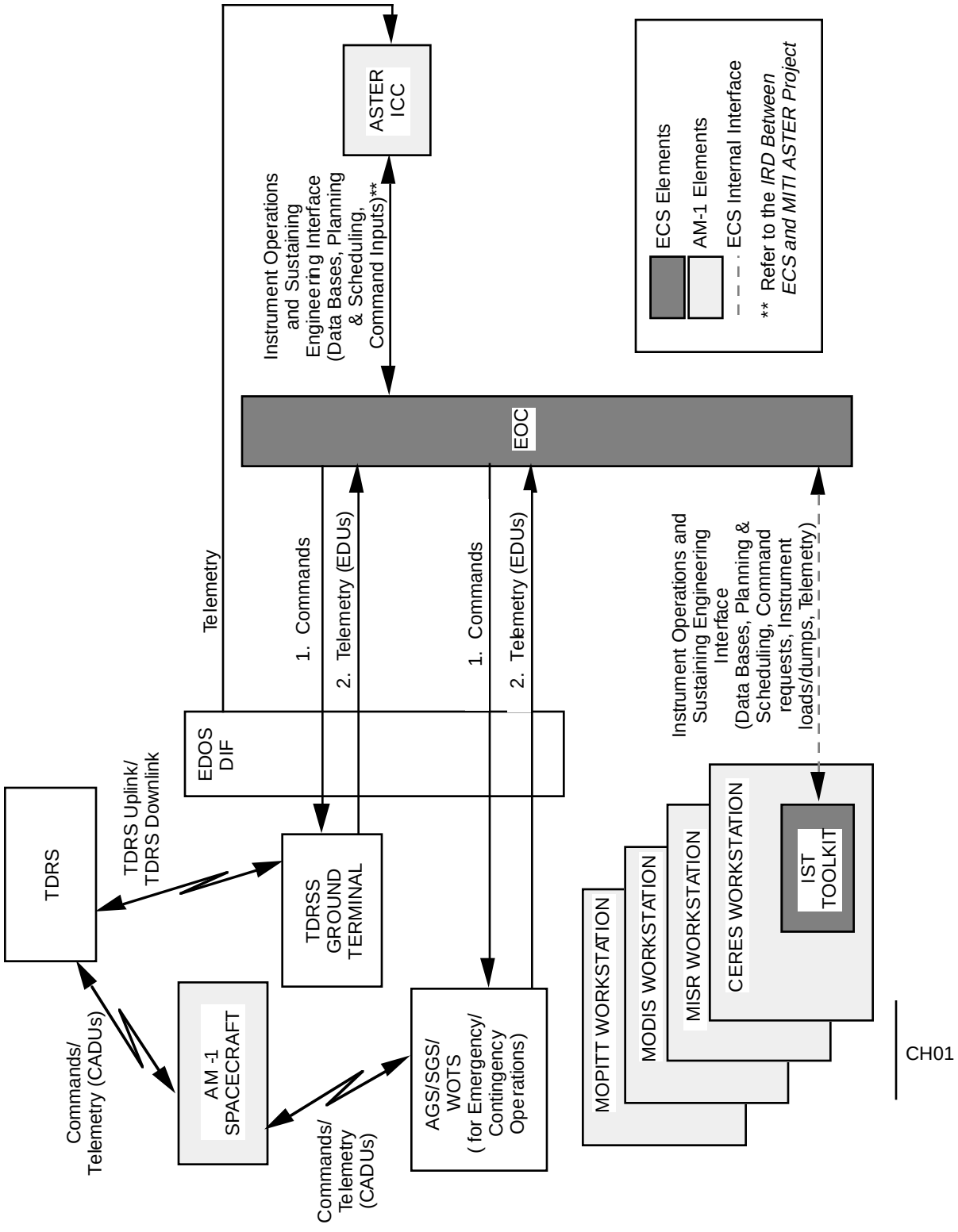

Figure 4-2. ECS/AM-1 Interfaces for Command and Telemetry

Spacecraft (ICD 106). The EOC forwards these commands, in the form of CLTUs to EDOS via Ecom [Table 4-1, Data Flow 1].

EDOS forwards the AM-1 digital command data to the appropriate TDRSS ground terminal (WSGT or STGT) for S-band radio frequency (RF) uplink to the AM-1 spacecraft through the scheduled TDRS.

AM-1 supports command receipt verification by inserting the appropriate CCSDS Command Operations Procedure (COP)-1 Command Link Control Word (CLCW) in the S-band telemetry Channel Access Data Units (CADUs) according to the guidelines described in ICD-106.

The AM-1 telemetry downlink is normally transported to the ground through TDRSS. The TDRSS ground terminal routes baseband CADUs to EDOS for processing and distribution.

EDOS records the CADUs, extracts the CCSDS packets and CLCWs, and processes the data based on physical channel, Virtual Channel Identifier (VCID), and packet Application Process Identifier (APID). Real time telemetry packets are inserted into EDOS Data Units (EDUs) and routed to the EOC and ASTER ICC via Ecom [Table 4-1, Data Flow 2]. EDOS also inserts CLCWs into EDUs and routes them to the EOC in real time for command receipt verification. The EOC uses the CLCW to determine if command retransmission to the spacecraft is required. EDOS performs Level 0 processing before sending the data to the DAACs for archival and data product generation.

AGS, SGS or WOTS command and telemetry support is used during contingencies; no science data are downlinked to these sites. From an ECS viewpoint, the format of command and telemetry data exchanged between the ECS elements and the AM-1 spacecraft through the AGS, SGS and WOTS ground stations is identical to the data formats transported through TDRSS. The EOC transmits CLTUs containing spacecraft and instrument command data to EDOS via Ecom in all cases [Table 4-1, Data Flow 1]. The data are then sent to AGS, SGS or WOTS. AM-1 receives the CLTUs via S-band ground station uplink. AM-1 telemetry CADUs are downlinked via S-band to the scheduled ground station (GN, JPL/DSN, or WOTS). The CADUs are routed to EDOS where the data are processed in the same manner as real time telemetry routed through TDRSS. EDOS forwards real time telemetry EDUs to the EOC and ASTER ICC via Ecom [Table 4-1, Data Flow 2]. EDOS also extracts and forwards CLCWs to the EOC for command receipt verification. CH01 CH01 CH01

4.2.2 Pre-launch Testing

ECS will participate in command and telemetry data flows to support AM-1 pre-launch tests, including spacecraft performance testing (at Valley Forge, PA and at VAFB), EOC/AM-1 compatibility testing, spacecraft thermal vacuum testing, Compatibility Test Van (CTV) testing, end-to-end testing, mission operations simulations, EOSDIS system integration testing, and EOSDIS Independent Verification & Validation (IV&V) testing. The format of command and telemetry data transmitted and received by the EOC during pre-launch testing will be identical to the EOC interface for spacecraft operations. For commanding, the EOC will output CLTUs; for

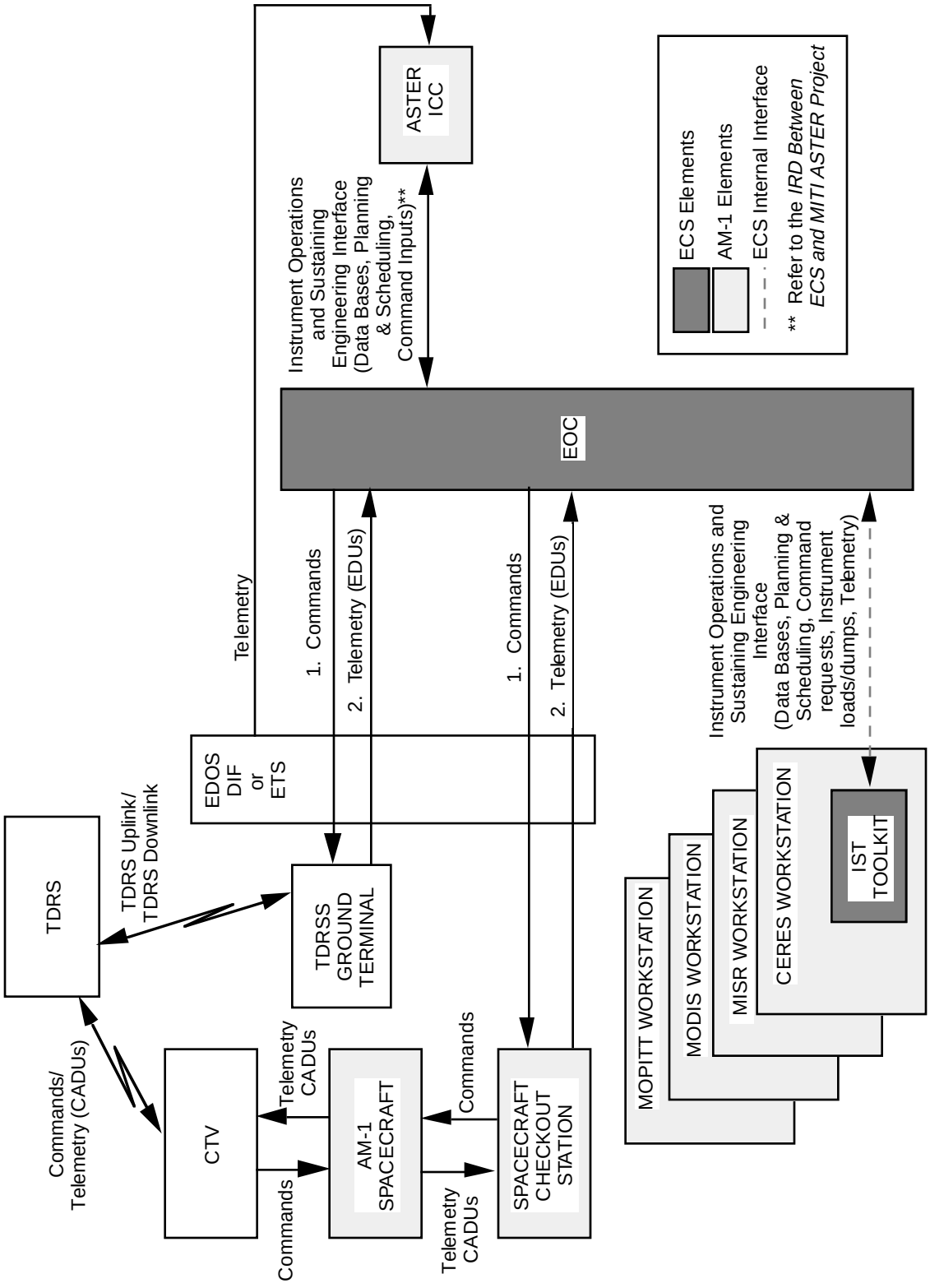

Figure 4-3. Representative Pre-Launch Testing Configurations

telemetry, the EOC will receive EDUs containing CLCWs or CCSDS telemetry packets (as defined in ICD-106) [Table 4-1, Data Flows 1 and 2]. Command and telemetry data will be transmitted and received over the Ecom network. The following paragraphs describe a few candidate data flow configurations (refer to Figure 4-3). Specific test configurations for these tests will be defined in the applicable AM-1, ESDIS, and Network test plans and procedures. As in on-orbit operations, the EOC transmits CLTUs to EDOS via Ecom. For testing, if EDOS is not available, the ETS can provide some EDOS-like functions. The EDOS/ETS forwards the AM-1 digital command data to the AM-1 SCS (also via Ecom). The SCS routes the command data to the AM-1 spacecraft.

Telemetry CADUs transmitted by the spacecraft are routed by the SCS through Ecom to EDOS or ETS. EDOS or ETS provides EDUs to the EOC containing the telemetry CCSDS packets and CLCWs.

The EOC also may participate in AM-1 Network compatibility tests with the Compatibility Test Van (CTV). During these tests, the EOC may supply command CLTUs to EDOS or ETS. For CTV testing, EDOS/ETS will deliver the data to the TDRSS ground terminal for uplink to the TDRS. The TDRS will transmit the S-band forward link to the CTV. The CTV will deliver the CLTUs to the AM-1 spacecraft. The CTV also will receive the spacecraft telemetry CADU data stream from the AM-1 spacecraft and uplink it to a TDRS. The return link telemetry flow from the TDRSS to the EOC will occur as described for on-orbit operations (see Section 4.2.1). CH01 CH01

SCS tapes containing test telemetry data (in CADU format) will be available to the ETS during the spacecraft I&T phase. The ETS can simulate EDOS inputs and outputs and play the data back to ECS elements at a later time, if requested.

4.2.3 Launch Interfaces

During launch and ascent, the EOC will be able to receive and monitor health and safety telemetry from the AM-1. The AM-1 will not receive commands from the EOC during this phase. The AM-1 interface to the EOC for launch telemetry is shown in Figure 4-4.

While in the launch vehicle, the AM-1 provides low-rate spacecraft health and safety telemetry through the umbilical to the launch vehicle. The Vandenberg Telemetry Relay Site (VTRS) receives the combined launch vehicle/AM-1 telemetry stream via direct connection while the launch vehicle is on the pad, and via the Advanced Range Instrumentation Aircraft (ARIA) and an Air Force Ground Station during ascent. The VTRS removes the AM-1 telemetry from the data stream and forwards the AM-1 telemetry to the launch site SCS for processing. The

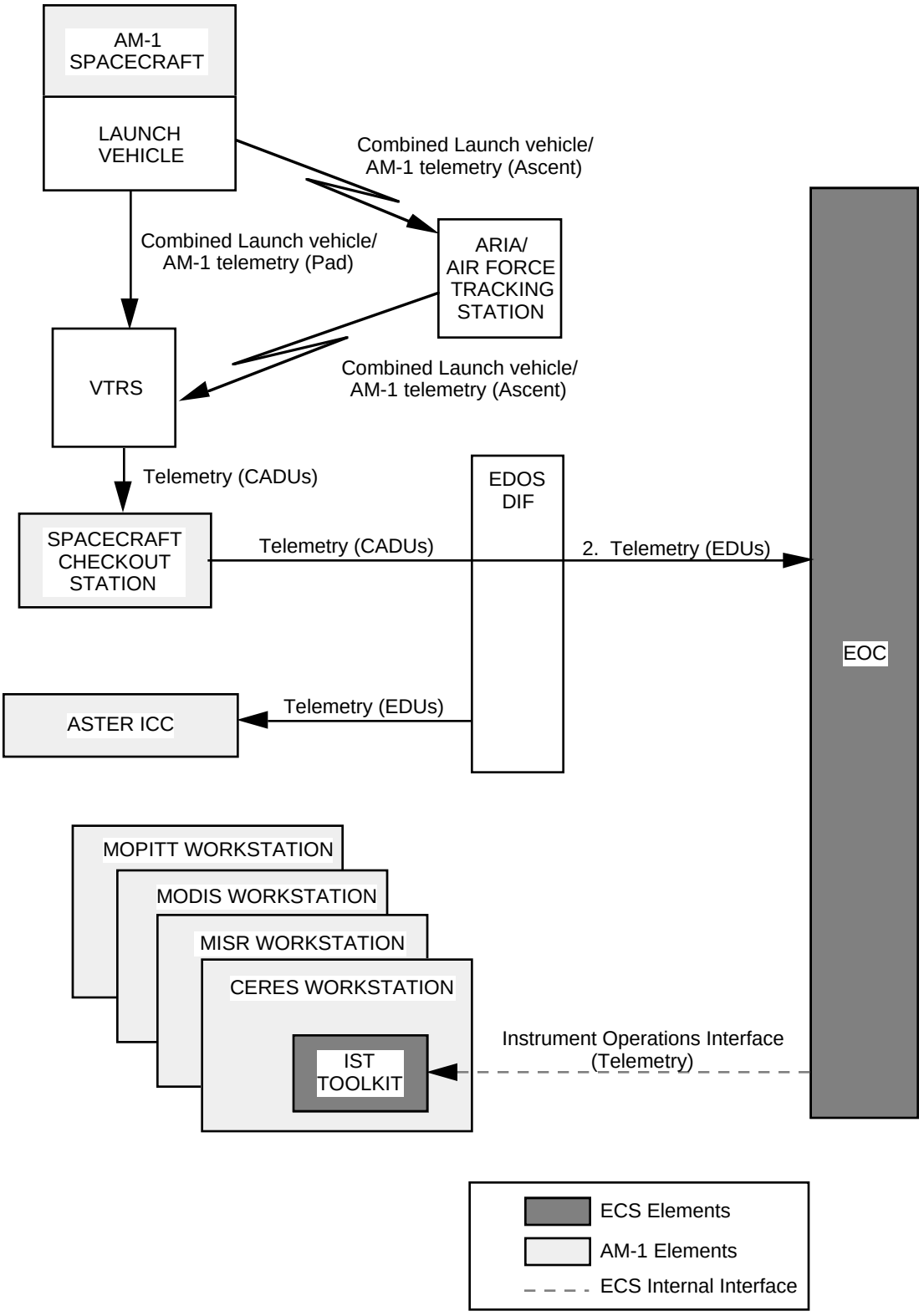

Figure 4-4. AM-1/EOC Launch Interfaces

AM-1 SCS forwards the AM-1 telemetry CADUs to EDOS, where they are forwarded (in EDU format) via Ecom links to the EOC for monitoring [Table 4-1, Data Flow 2].

4.3 Spacecraft Simulator Interfaces

The SSIM will be used by the AM-1 flight operations team for command procedure development and validation (including validating flight software updates and SCC loads), flight operator training, and anomaly investigation support. The SSIM allows the flight operations team to observe the effects of specific EOC-defined command sequences on the AM-1 spacecraft. The EOC/SSIM interface is depicted in Figure 4-1.

The EOC/SSIM interface will support all operational AM-1 command data rates. The EOC provides command sequences to the SSIM to simulate certain spacecraft situations, including failures, to allow investigation of spacecraft behavior during pre-defined situations. The SSIM accepts AM-1 commands in CLTU format [Table 4-1, Data Flow 3], processes the commands, and outputs to the EOC realistic simulated spacecraft telemetry for all spacecraft equipment modules, assemblies, and instruments [Table 4-1, Data Flow 4]. The SSIM also will output updated CLCWs, in response to the commands that it receives. Details of telemetry interface between the SSIM and EOC will be defined in the ICD Between the EOS AM-1 Spacecraft Simulator and the ECS . These details include the communications link between the SSIM and the EOC and the format of the telemetry output from the SSIM (CADUs). The simulated AM-1 and instrument telemetry data will be received by the EOC in the form of CCSDS packets. CH02

4.4 Pre-mission Interfaces

This section describes the delivery of data bases and software to support pre-mission tests and subsequent for on-orbit operations. These pre-mission interfaces are shown in Figure 4-1.

4.4.1 Data Base Delivery

Each instrument team will provide an instrument data base information in the form of an Instrument Data Base (IDB) to AM-1 spacecraft vendor. The IDB will contain the instrument command and telemetry parameters required for commanding and monitoring (instrument telemetry formats, limits, calibration curves, command procedures, etc.). The AM-1 spacecraft vendor will be responsible for the preparation of the Spacecraft Data Base (SDB) which defines the corresponding AM-1 spacecraft command and telemetry parameters.

The AM-1 spacecraft vendor will form the Project Data Base (PDB) by merging the AM-1 SDB and the IDBs. This PDB will be used by the AM-1 spacecraft vendor during spacecraft and instrument I&T. The AM-1 spacecraft vendor will deliver the approved PDB file to the EOC for use in pre-launch testing and operations [Table 4-1, Data Flow 5].

The AM-1 spacecraft vendor /EOC interface for PDB transfer is only required for pre-launch and early orbit activities. After on-orbit operations begin, the instrument teams will deliver updated IDBs (as required) directly to the EOC using the IST toolkit (refer to Section 4.5).

4.4.2 Spacecraft Analysis Software Delivery

The SAS will be developed by the AM-1 spacecraft vendor, delivered to ECS, and integrated into an EOC off-line system to support AM-1 sustaining engineering and analysis [Table 4-1, Data Flow 6]. The integrated SAS will receive, process, and analyze spacecraft health and safety data in an off-line mode to track spacecraft performance trends, detect and analyze spacecraft anomalies, and evaluate subsystem performance. SAS results are reported to the AM-1 flight operations team via displays and reports in the EOC.

4.4.3 IST Toolkit Delivery

The IST toolkit is an ECS-developed software package that provides individuals who are not physically located at the EOC access to the EOC. ECS will deliver the IST toolkit software to the AM-1 instrument teams before AM-1 launch [Table 4-1, Data Flow 7]. The IST toolkit software will be hosted on workstations provided by the instrument teams at the PI/TL facilities.

4.5 Instrument Support Terminal Toolkit Interfaces

The IST toolkit software will reside on a PI/TL-provided workstation and will enable PIs/TLs for non-complex instruments (such as CERES, MISR, MODIS, and MOPITT) to participate in the planning, scheduling, monitoring, and analysis of their instruments. IST toolkit interfaces are shown in Figure 4-1. Instrument operations and sustaining engineering functions are accommodated by the interface between the ECS EOC and the ECS IST toolkit, specifically through the exchange of data base information; planning and scheduling information; instrument command requests; instrument microprocessor loads/dumps; and spacecraft and instrument housekeeping telemetry. The IST toolkit also has access to archived instrument engineering data from ECS. Communications between the EOC and the IST toolkit will be supported via the ESN or NSI. The interface requirements for the ECS IST toolkit-to-ECS EOC interface defined in the Functional and Performance Requirements Specification for the ECS. Concepts for instrument operations using the IST toolkit are addressed in the ECS Operations Concept Document for the ECS Project. Details of instrument operations using the IST toolkit will be negotiated with the AM-1 Project; these plans will be documented in operations documents which will be developed by the AM-1 Project Office for each instrument.

The IST toolkit also will be capable of importing or exporting data from the host PI/TL system. Examples of imported data are instrument microprocessor or table load data, which may be forwarded to the EOC for upload to the instrument [Table 4-1, Data Flow 8]. Examples of exported data are instrument microprocessor/table dumps or instrument analysis results [Table 4-1, Data Flow 9].

4.6 Flight Software Maintenance

AM-1 flight software maintenance will be performed at the SDVF. The EOC/SDVF interface is shown in Figure 4-1. The SDVF provides AM-1 flight software loads and updates to the EOC for uplink to the AM-1 spacecraft [Table 4-1, Data Flow 10]. The EOC also provides the SDVF with AM-1 spacecraft flight software dumps, as required [Table 4-1, Data Flow 11]. Interface details between the EOC and the SDVF will be documented in the ICD Between ECS and the Software Development and Validation Facility for the EOS AM-1 Project.

5. Functional and Performance Interface Requirements

5.1 Requirements Traceability

The functional and performance interface requirements identified in this document will be traced to the following parent documents:

a. Functional and Performance Requirements Specification for the ECS

b. EOSDIS Core System Statement of Work

c. Earth Science Data and Information System (ESDIS) Project -- Level 2 Requirements

d. EOS-AM Ground System Requirements

The following sections list the functional and performance interface requirements for ECS and AM-1 elements. Functional and performance requirements for Ecom are documented in the Ecom Functional and Performance Requirements Specification and Table 4 of the EDOS and Ecom Requirements document.

5.2 Functional Interface Requirements

5.2.1 Command and Telemetry Interface Requirements

5.2.1.1 On-orbit Operations Interface Requirements

AM1-0020	The EOC shall have the capability to send (via EDOS/Ecom and the SN, AGS, SGS or WOTS) and the AM-1 spacecraft shall have the capability to receive spacecraft commands in CCSDS CLTUs (as defined in AM-1 ICD 106).	CH01
AM1-0030	The EOC shall have the capability to send (via EDOS/Ecom and the SN, AGS, SGS or WOTS) and the AM-1 spacecraft shall have the capability to receive instrument commands in CCSDS CLTUs (as defined in AM-1 ICD 106).	CH01
AM1-0050	The AM-1 spacecraft shall have the capability to send (in CADU format) and the EOC shall have the capability to receive (in EDUs containing CCSDS telemetry packets and CLCWs) real time AM-1 spacecraft and instrument housekeeping telemetry packets (as defined in AM-1 ICD 106) via EDOS/Ecom and the SN, AGS, SGS or WOTS interfaces.	CH01
AM1-0070	The AM-1 spacecraft shall have the capability to send (in CADU format) and the EOC shall have the capability to receive (in EDUs containing CCSDS telemetry packets) recorded AM-1 spacecraft and instrument housekeeping telemetry packets (as defined in AM-1 ICD 106) via EDOS/Ecom and the SN, AGS, SGS or WOTS interfaces.	CH01

AM1-0090 The AM-1 spacecraft shall have the capability to send (in CADU format) and the EOC shall have the capability to receive (in EDUs containing CCSDS telemetry packets and CLCWs) AM-1 SCC, CTIU, and instrument microprocessor memory dump telemetry packets (as defined in AM-1 ICD 106) via EDOS/Ecom and the SN, AGS, SGS or WOTS interfaces. CH01

5.2.1.2 Pre-launch Testing Interface Requirements

AM1-0120 The EOC shall have the capability to send and the AM-1 spacecraft shall have the capability to receive spacecraft commands in CCSDS CLTUs (as defined in AM-1 ICD 106) via pre-launch test configurations which include the AM-1 Spacecraft Checkout Station, Ecom, and EDOS or ETS.

AM1-0125 The AM-1 spacecraft shall have the capability to send (in CADU format) and the EOC shall have the capability to receive (in EDUs containing CCSDS telemetry packets and CLCWs) real time AM-1 housekeeping telemetry packets (as defined in AM-1 ICD 106) via pre-launch test configurations which include the AM-1 Spacecraft Checkout Station, Ecom, and EDOS or ETS.

AM1-0130 The AM-1 spacecraft shall have the capability to send (in CADU format) and the EOC shall have the capability to receive (in EDUs containing CCSDS telemetry packets and CLCWs) recorded AM-1 housekeeping telemetry packets (as defined in AM-1 ICD 106) via pre-launch test configurations which include the AM-1 Spacecraft Checkout Station, Ecom, and EDOS or ETS.

AM1-0135 The AM-1 spacecraft shall have the capability to send (in CADU format) and the EOC shall have the capability to receive (in EDUs containing CCSDS telemetry packets and CLCWs) AM-1 SCC, CTIU, and instrument microprocessor memory dump telemetry packets (as defined in AM-1 ICD 106) via pre-launch test configurations which include the AM-1 Spacecraft Checkout Station, Ecom, and EDOS or ETS.

5.2.1.3 Launch Interface Requirements

AM1-0140 The SCS shall have the capability to send (in CADU format) and the EOC shall have the capability to receive (in EDUs containing CCSDS telemetry packets) AM-1 spacecraft telemetry data (as defined in AM-1 ICD-106) during spacecraft launch via launch configurations which include EDOS and Ecom.

5.2.2 Spacecraft Simulator Interface Requirements

AM1-0150 The EOC shall have the capability to send and the SSIM shall have the capability to receive AM-1 spacecraft and instrument commands in CCSDS CLTU format (as defined in AM-1 ICD-106).

AM1-0160 The SSIM shall have the capability to send and the EOC shall have the capability to receive simulated real time AM-1 spacecraft and instrument housekeeping telemetry and Command Link Control Words (as defined in AM-1 ICD-106)[4].

AM1-0170 (Deleted) CH02

AM1-0200 The SSIM shall have the capability to send and the EOC shall have the capability to receive simulated AM-1 SCC, CTIU, and instrument microprocessor memory dump telemetry and Command Link Control Words (as defined in AM-1 ICD-106)[4].

5.2.3 Pre-mission Interface Requirements

AM1-0215 The AM-1 spacecraft vendor shall have the capability to provide and the EOC shall have the capability to receive, AM-1 project data base information containing both spacecraft and instrument parameters.

AM1-0220 The ECS shall have the capability to provide and the MISR, MOPITT, MODIS, and CERES PIs/TLs shall have the capability to receive IST toolkit software, IST toolkit software upgrades, and IST toolkit documentation.

AM1-0225 The AM-1 spacecraft vendor shall have the capability to provide and ECS shall have the capability to receive spacecraft analysis tools for implementation and integration into the EOC.

5.2.4 IST Toolkit Interface Requirements

AM1-0230 The IST toolkit shall have the capability to accept data from a science computing facility that supports PI/TL operations, which include the following data (at a minimum):

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[4] The SSIM outputs telemetry in CADU format. The EOC receives the telemetry as CCSDS packets and CLCWs. CADU-to-CCSDS packet conversion is performed by the ETS.

a. instrument microprocessor memory loads.

b. changes in the instrument parameters.

AM1-0240 The IST toolkit shall have the capability to provide data to a science computing facility that supports PI/TL instrument operations, which include the following data (at a minimum):

a. Microprocessor memory dumps.

b. Instrument analysis results.

5.2.5 Flight Software Maintenance Interface Requirements

AM1-0270 The AM-1 SDVF shall have the capability to send and ECS shall have the capability to receive AM-1 SCC flight software updates.

AM1-0280 ECS shall have the capability to send and the AM-1 SDVF shall have the capability to receive AM-1 SCC flight software dumps.

5.2.6 Training Interface Requirements

AM1-0310 The ECS contractor shall provide and the AM-1 spacecraft vendor shall receive training on operations of the FOS.

AM1-0315 The ECS contractor shall provide and the AM-1 instrument teams shall receive training on operations of the IST toolkit.

AM1-0320 The AM-1 spacecraft vendor shall provide and the ECS contractor shall receive AM-1 spacecraft operations training.

AM1-0330 The AM-1 instrument teams shall provide and the ECS contractor shall receive AM-1 instrument operations training.

5.2.7 Documentation Interface Requirements

AM1-0340 The AM-1 project shall have the capability to provide and ECS shall have the capability to accept and store AM-1 spacecraft and instrument hardware and software technical documentation.

5.3 Performance Interface Requirements

AM1-1000 ECS functions shall have an operational availability (computed as defined in the Functional and Performance Requirements Specification for the ECS) of 0.96 at a minimum and a mean down time (MDT) of four (4) hours or less, unless otherwise specified.

AM1-1010 The ECS FOS shall have an operational availability of 0.9998 at a minimum and a MDT of one (1) minute or less for critical real time functions that support:

a. Launch

b. Early orbit checkout

c. Disposal

d. Orbit adjustment

e. Anomaly investigation

f. Recovery from safe mode

g. Routine real time commanding and associated monitoring for spacecraft and instrument health and safety

AM1-1020 The ECS FOS shall have an operational availability of 0.99925 at a minimum and a MDT of five (5) minutes or less for non-critical real time functions.

AM1-1050 The EOC shall support several uplink rates to the spacecraft, which include at a minimum the following:

a. 10 kilobits per second (kbps) (SSA uplink)

b. 1 kbps (S-band MA uplink)

c. 125 bits per second (bps) (SSA uplink during contingency operations)

d. 2 kbps (emergency operations via S-band) CH01

AM1-1060 The EOC shall be capable of simultaneously receiving all AM-1 telemetry data types.

AM1-1070 The EOC shall provide the capability to receive and process real-time data received as two 16 kbps data streams.

AM1-1080 The EOC shall provide the capability to receive and record spacecraft recorder data at rates up to 1.544 Mbps.

AM1-1090 The EOC shall be capable of providing CLTUs to the SSIM at the following data rates:

a. 125 bps

b. 1 kbps

c. 2 kbps

d. 10 kbps

AM1-1100 The EOC shall be capable of receiving two housekeeping telemetry packet streams of 16 kbps from the SSIM[5].

AM1-1110 The EOC shall be capable of receiving a health and safety telemetry packet stream from the SSIM at 1 kbps[5].

AM1-1120 The EOC shall be capable of receiving a diagnostic telemetry/memory dump packet stream from the SSIM at 16 kbps[5].

AM1-1130 (Deleted) CH02

AM1-1150 ECS shall contribute a loop delay of not greater than 2.5 seconds of the total system delay of five (5) seconds for emergency real-time commands, not including the time needed for command execution. The loop delay is measured from the originator to the spacecraft/instrument and back and only applies when a Tracking and Data Relay Satellite System (TDRSS) link is available for contact to the spacecraft.

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[5] The SSIM outputs telemetry in CADU format. The EOC receives the telemetry as CCSDS packets and CLCWs. CADU-to-CCSDS packet/CLCW conversion is performed by the ETS.

6. Interface Control Documentation Plan

The ICDs and other lower level documents which correspond to this IRD are listed in Table 6-1. These documents will define the functional and physical design of each interface between ECS and the AM-1 elements and will include the precise data contents and format of each interface. All modes (options) of data exchange for each interface will be described as well as the conditions required for each mode or option. Additionally, data rates, duty cycles, error conditions, and error handling procedures will be included. The sequence of exchanges will be completely described (e.g., required handshaking). Communications protocols or physical media will be detailed for each interface. These documents will be controlled by AM Project and/or ESDIS Configuration Control. Responsibility for development of these documents is specified in Table 6-1.

Table 6-1. ECS/AM-1 Interface Documentation (1 of 2)

Document	*Documentation Responsibility*	*Schedule*
Interface Control Document (ICD) Data Format Control Book for EOS-AM Spacecraft (ICD-106)	AM-1	Completed
Interface Control Document Between the EOS AM-1 Spacecraft Simulator and EOC	AM-1	Preliminary: ECS Release A PDR - 1 month Final: ECS FOS CDR - 2 weeks (October 1995)
Interface Control Document Between the ECS and the Software Development and Validation Facility	ECS	Preliminary: ECS Release A PDR - 1 month Final: ECS FOS CDR - 2 weeks (October 1995))
Data Format Control Document (DFCD) for the EOS AM-1 Project Data Base	ECS	Preliminary: ECS Release A PDR - 1 month Final: ECS FOS CDR - 2 weeks (October 1995)
Interface Control Document Between EOC and EOS AM-1 Spacecraft Analysis Software	ECS	Preliminary: ECS Release A PDR - 1 month Final: ECS FOS CDR - 2 weeks (October 1995)
ECS Instrument Support Terminal (IST) Toolkit Capabilities Document	ECS	Completed

Table 6-1. ECS/AM-1 Interface Documentation (2 of 2)

Document	*Documentation Responsibility*	*Schedule*
ECS Operator's Manual (DID 611/OP3) (includes the IST toolkit)	ECS	Preliminary: ECS Release A RRR - 1 month (November 1996) Final: ECS Release B RRR - 1 month (August 1997)
EOSDIS Core System Training Plan (DID 622/OP2)	ECS	Preliminary: ECS Release B IDR - 1 month (July 1995) Final: ECS Release B CDR - 1 month (February 1996)
EOS-AM Training Plan (OPD-410)	AM-1	TBS

Abbreviations and Acronyms

AGS	Alaska Ground Station	CH01
APID	Application Process Identifier	
ARIA	Advanced Range Instrumentation Aircraft	
ASF	Alaska SAR Facility (DAAC)	
AST	ASTER Science Team	
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer	
bps	bits per second	
C&DH	Command and Data Handling	
C&DHS	Command and Data Handling Subsystem (AM-1)	
CADU	Channel Access Data Unit	
CCB	Configuration Control Board	
CCD	charged coupled device	
CCR	Configuration Change Request	
CCS	Common Carrier Subsystem (Ecom)	
CCSDS	Consultative Committee for Space Data Systems	
CDR	Critical Design Review	
CDRL	Contract Data Requirements List	
CERES	Clouds and Earth's Radiant Energy System	
CLCW	Command Link Control Word	
CLTU	Command Link Transmission Unit	
COMMS	Communication Subsystem (AM-1)	
COP	Command Operations Procedure	
CSA	Canadian Space Agency	
CSMS	Communications and System Management Segment	
CTIU	Command and Telemetry Interface Unit (AM-1)	
CTV	Compatibility Test Van	
DAAC	Distributed Active Archive Center	
DADS	Data Archive and Distribution System	
DAS	Direct Access System (AM-1)	

DB	Direct Broadcast (AM-1)
DCN	document change notice
	CH01
DDL	Direct Downlink (AM-1)
DFCD	Data Format Control Document
DFRD	Data Format Requirements Document
DID	Data Item Description
DMR	Detailed Mission Requirements
DP	Direct Playback (AM-1)
	CH01
EAS	Electrical Accommodation Subsystem (AM-1)
Ecom	EOS Communications
ECS	EOSDIS Core System
EDC	EROS Data Center (DAAC)
EDOS	EOS Data and Operations System
EDU	EDOS Data Unit
EGS	EOS Ground System
EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EPS	Electrical Power Subsystem (AM-1)
EROS	Earth Resources Observation System
ESA	European Space Agency
ESDIS	Earth Science Data and Information System
ESN	EOSDIS Science Network
ESS	Engineering Support Subsystem (Ecom)
ETS	EOSDIS Test System
F&PRS	Functional and Performance Requirements Specification
FDF	Flight Dynamics Facility (GSFC)
FOS	Flight Operations Segment

CH01

GDS	Ground Data System (ASTER)
GFE	Government Furnished Equipment

CH01

GN&CS	Guidance, Navigation, and Control Subsystem (AM-1)
GSFC	Goddard Space Flight Center
HGA	high gain antenna (AM-1)
I&T	integration and test
ICC	Instrument Control Center
ICD	Interface Control Document
ICF	Instrument Control Facility
ICWG	Interface Control Working Group
ID	Identifier
IDB	Instrument Data Base
IDR	Incremental Design review
IFOU	Instrument Flight Operations Understanding
IMS	Information Management System
IODB	Instrument Operational Data Base
IP	International Partner, Internet Protocol
IRD	Interface Requirements Document
IST	Instrument Support Terminal
IV&V	independent verification and validation

CH01

kbps	kilobits per second
KSA	Ku-band single access
LaRC	Langley Research Center
MA	Multiple Access
Mbps	megabits per second
MDT	mean down time
MHz	megahertz
MISR	Multi-Angle Imaging Spectro-Radiometer

MITI	Ministry of International Trade and Industry (Japan)
MO&DSD	Mission Operations and Data Systems Directorate (GSFC Code 500)
MODIS	Moderate Resolution Imaging Spectroradiometer
MOM	Mission Operations Manager
MOPITT	Measurement of Pollution in the Troposphere
MSFC	Marshall Space Flight Center
NASA	National Aeronautical and Space Administration
Nascom	NASA Communications
NCC	Network Control Center (GSFC)
NMS	Network Management Subsystem (Ecom)
NOCC	Network Operations Control Center (DSN)
NSI	NASA Science Internet
NSIDC	National Snow and Ice Data Center
ODB	Operational Data Base
ORNL	Oak Ridge National Laboratory (DAAC)
PDB	Project Data Base
PDR	Preliminary Design Review
PGS	Product Generation System
PI	Principal Investigator
PROPS	Propulsion Subsystem (AM-1)
PSCN	Program Support Communications Network
RF	radio frequency
RIR	Release Initiation Review
RRR	Release Readiness Review
S/C	spacecraft
SAR	Synthetic Aperture Radar
SAS	Spacecraft Analysis Software
SCC	Spacecraft Control Computer (AM-1)
SCF	Science Computing Facility
SCS	Spacecraft Checkout Station
SCS	Spacecraft Contact Session

CH01

SDB	Spacecraft Data Base
SDF	Software Development Facility
SDPS	Science Data Processing Segment (ECS)
SDR	System Design Review
SDVF	Software Development and Validation Facility
SEF	Sustaining Engineering Facility (EDOS)
SFE	Science Formatting Equipment (AM-1)
SGS	Svalbard Ground Station CH01
SMC	System Management Center
SMS	Structures and Mechanisms Subsystem (AM-1)
SN	Space Network
SOW	Statement of Work
SSA	S-band Single Access
SSIM	Spacecraft Simulator
STDN	Spaceflight Tracking and Data Network
STGT	Second TDRSS Ground Terminal
SWIR	shortwave infrared
TBD	to be determined
TBS	to be supplied
TCP	Telemetry and Command Processor (MODIS)
TCS	Thermal Control Subsystem (AM-1)
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TGT	TDRSS Ground Terminal
TIR	thermal infrared
TL	Team Leader
TOO	target of opportunity
TS	Transport Subsystem (Ecom)
TT&C	tracking, telemetry, and command
U.S.	United States
UDP	User Datagram Protocol
VAFB	Vandenberg Air Force Base
VCID	Virtual Channel Identifier

VNIR	visible and near infrared
VTRS	Vandenburg Telemetry Relay Site
WFF	Wallops Flight Facility
WAN	Wide Area Network
WOTS	Wallops Orbital Tracking Station
WSC	White Sands Complex
WSGT	White Sands Ground Terminal
WSMC	Western Space and Missile Center